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Accounting Implications of Using AI to Enhance Incentives for Wireless Energy Transmission in Smart Cities

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Abstract
The integration of Artificial Intelligence (AI) into wireless energy transmission systems within smart cities represents a transformative shift in how urban environments manage and distribute energy. This technological evolution, driven by AI, aims to optimize energy usage, enhance grid efficiency, and reduce environmental footprints. However, the implementation of AI-powered wireless energy transmission brings with it complex accounting implications that require careful consideration by businesses, municipalities, and stakeholders. This explores the financial and accounting considerations associated with leveraging AI to enhance incentives for wireless energy transmission. It delves into the costs associated with adopting AI technologies, including capital investments in infrastructure, software, and the operational expenses for system maintenance and upgrades. Additionally, the impact of governmental and corporate incentives, such as tax credits and subsidies, is examined to understand how they influence the financial viability and attractiveness of these technologies for stakeholders. Revenue recognition models are explored, particularly in the context of dynamic pricing, energy savings, and usage-based billing enabled by AI. This further discusses the accounting treatment of incentives offered by governments and corporations, along with the financial reporting requirements surrounding these incentives. It emphasizes the importance of transparent reporting practices, the valuation of AI systems, and the implications of financial risk management due to uncertainties related to AI adoption, such as technical failures, cybersecurity risks, and energy market volatility. Ultimately, the study concludes by outlining the long-term financial sustainability of AI-driven wireless energy systems and the need for forward-looking accounting strategies to ensure successful integration within smart city infrastructures. By addressing these accounting implications, the review provides valuable insights for entities investing in AI-powered energy solutions to balance financial goals with the environmental and economic objectives of smart cities.

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1. Introduction

Smart cities are urban areas that leverage digital technologies, data analytics, and interconnected systems to enhance the quality of life for their residents, improve operational efficiency, and reduce the overall environmental impact (Bibri and Krogstie, 2020; Rehan, 2023) [10, 47]. Defined by their reliance on advanced technologies, smart cities utilize Internet of Things (IoT) devices, data-driven decision-making, and automation to optimize city functions such as transportation, healthcare, energy distribution, and public safety. These cities aim to be sustainable, resilient, and livable, addressing the challenges posed by urbanization, climate change, and resource constraints. The adoption of technologies like 5G, AI, and big data analytics has paved the way for smarter infrastructure and services that are more responsive to the needs of citizens and more efficient in terms of resource usage (Mukherjee *et al*., 2022; Alahi *et al*., 2023) [41, 4].

In the context of smart cities, technology plays a pivotal role in shaping the urban landscape. Artificial Intelligence (AI), in particular, stands out as a key enabler of transformation, driving innovation in areas such as energy management, transportation, healthcare, and public services (Olawale *et al*., 2023) [43]. AI's ability to process vast amounts of data and make real-time decisions provides cities with the tools to streamline operations, predict future demands, and adapt to emerging challenges. As smart cities become increasingly complex, the integration of AI helps to enhance the decision-making process, optimize resource distribution, and facilitate better governance and service delivery (Kalusivalingam *et al*., 2021; Bokhari and Myeong, 2022) [27, 11].

Wireless energy transmission is a crucial technology in the evolving landscape of smart cities (Javed *et al*., 2022) [25]. Unlike traditional wired systems, wireless energy allows for the transfer of power over distances without the need for physical connections, offering a range of benefits. One of the key advantages of wireless energy is its efficiency. By reducing energy losses typically associated with traditional transmission methods, wireless systems can deliver power more effectively. This increase in efficiency is particularly vital as energy demand grows in urban environments, where maintaining a sustainable energy supply is increasingly challenging. Additionally, flexibility is another significant benefit of wireless energy transmission. It allows for the dynamic and mobile distribution of power, making it easier to integrate renewable energy sources like solar and wind, which often require decentralized distribution networks. Wireless systems are also more adaptable to changing urban environments, where infrastructure and building designs can vary (Khalifeh *et al*., 2021) [29]. This flexibility supports the integration of energy into new and existing structures without major renovations or extensive wiring. From an environmental perspective, wireless energy transmission can help reduce the carbon footprint of energy distribution. As cities aim to become more sustainable, minimizing the need for traditional grid infrastructure reduces both the direct environmental impact of construction and the indirect emissions associated with energy losses in transmission. This makes wireless energy transmission a vital component of green energy initiatives in smart cities, further aligning urban development with sustainability goals.

AI plays a crucial role in optimizing both the distribution and consumption of energy within smart cities, particularly when paired with wireless energy transmission technologies (Mahmood *et al*., 2021) [36]. Enhancing energy distribution involves using AI algorithms to analyze real-time data from energy grids, weather patterns, and consumption trends to predict energy demands and adjust supply accordingly. This predictive capability allows for more efficient use of available resources, preventing energy shortages or wastage. AI can also monitor the condition of energy networks, identifying potential faults or inefficiencies before they escalate, ensuring smoother and more reliable energy distribution across urban areas. Moreover, optimization of wireless energy transmission through AI is an essential development in the pursuit of more efficient and sustainable smart city infrastructures. AI enables the continuous optimization of energy flow by dynamically adjusting the distribution patterns in response to fluctuating demand or changes in environmental conditions (Hua *et al*., 2021; Stecuła *et al*., 2023) [22, 52]. Through machine learning and data analysis, AI can forecast energy consumption patterns, helping to balance supply and demand, and reduce energy losses associated with traditional transmission methods. AI's ability to continuously learn and adapt ensures that wireless energy systems in smart cities can evolve in response to changing energy landscapes, improving the overall efficiency and reliability of energy systems (Zhang *et al*., 2021; Huseien and Shah, 2022).

This aims to explore the accounting implications of AI-driven wireless energy systems within smart cities. As these technologies grow in importance, understanding their financial impacts on organizations, municipalities, and other stakeholders is crucial. The adoption of AI for energy optimization introduces new cost structures, revenue models, and financial risks that must be accounted for in order to create sustainable and profitable energy systems. Additionally, incentives both governmental and corporate play a critical role in encouraging the widespread adoption of AI technologies and renewable energy solutions in urban infrastructure. The accounting implications of these incentives, including subsidies, tax credits, and investment models, will be thoroughly analyzed. Furthermore, the outline will delve into understanding the role of incentives in the adoption and integration of this technology. By examining the financial incentives provided by governments and corporations, this will explore how such incentives can reduce financial barriers, accelerate technological adoption, and influence long-term sustainability goals. Through this exploration, the study will provide a comprehensive view of how accounting practices must evolve in the context of smart cities, AI, and wireless energy transmission to support these innovations. This analysis is vital for businesses, financial analysts, and policymakers who seek to navigate the financial landscape of smart city technologies.

2. Methodology

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology is a structured approach to conducting systematic reviews and meta-analyses. In the context of the study on "Accounting Implications of Using AI to Enhance Incentives for Wireless Energy Transmission in Smart Cities," the PRISMA methodology will guide the process of identifying, selecting, and analyzing relevant literature.

A comprehensive search will be conducted across multiple academic databases such as Google Scholar, JSTOR, Scopus, Web of Science, and IEEE Xplore, using specific keywords like "AI," "accounting implications," "wireless energy transmission," "smart cities," "incentives," "costs," and "financial reporting." The inclusion criteria will focus on peer-reviewed articles, books, reports, and white papers published in English since 2000, addressing the integration of AI in wireless energy transmission systems with a specific focus on financial and accounting perspectives. Studies that do not focus on accounting implications or do not relate to AI or wireless energy transmission in the context of smart cities will be excluded.

After the search is conducted, duplicate articles will be removed, and the remaining titles and abstracts will be reviewed. Full-text reviews will then be carried out to ensure the studies are relevant to the research question. Articles that do not meet the inclusion criteria will be excluded at this stage. Two independent reviewers will assess the studies to ensure consistency and reliability in the selection process.

The selected studies will cover topics such as the accounting for capital costs and operational expenses in AI-powered wireless energy systems, the financial impact of governmental and corporate incentives, revenue recognition models influenced by dynamic energy pricing, financial reporting requirements for AI and renewable energy systems, and cost-benefit analyses. Data will be extracted from these studies, including key findings, authorship, methodologies, and accounting frameworks used in the studies.

A thematic analysis will be performed to synthesize the findings from the selected studies, identifying key themes such as cost structures, incentive mechanisms, financial risks, and revenue recognition. If applicable, quantitative data such as cost savings and ROI metrics reported in the studies will be analyzed to uncover trends in the accounting implications of AI-driven energy systems.

The quality of each study will be assessed using risk-of-bias tools and methodology evaluation instruments to ensure the studies are reliable and relevant. A PRISMA flow diagram will be used to visually represent the study selection process, indicating the number of records identified, screened, assessed for eligibility, and included in the final review.

The final report will summarize the key findings, categorizing the accounting implications into relevant themes, and will provide recommendations for future research. Additionally, the review will offer insights for accounting professionals, energy providers, and policymakers on the financial and accounting challenges associated with AI in wireless energy transmission. Future research directions will be proposed, particularly regarding the long-term sustainability and evolving accounting standards in smart city infrastructure.

This PRISMA-based approach will ensure a transparent, replicable, and comprehensive review of the accounting implications of using AI to enhance wireless energy transmission in smart cities.

2.1 The Role of AI in wireless energy transmission

Wireless energy transmission (WET) is an innovative field that aims to provide energy without the use of traditional wires or cables (López *et al*., 2021). This technology, which leverages electromagnetic fields to transmit power, has the potential to revolutionize how energy is distributed across industries, homes, and electronic devices. Artificial intelligence (AI) is playing an increasingly crucial role in optimizing the efficiency, distribution, and management of wireless energy transmission systems as shown in figure 1. By integrating AI, energy networks can become more adaptive, intelligent, and efficient, addressing several challenges associated with energy supply and consumption.

One of the most significant contributions of AI to wireless energy transmission is the optimization of energy distribution. AI algorithms are pivotal in balancing energy supply with demand, which is essential for maintaining the stability of energy grids and minimizing waste (Mazhar *et al*., 2023). AI-based models can process vast amounts of data from multiple sources, including weather patterns, energy consumption trends, and grid status, to predict energy demand with high accuracy. This predictive capability allows energy providers to adjust the transmission of energy accordingly, ensuring that power is available where it is needed most without overloading the system or creating waste. In addition, predictive analytics powered by AI is particularly effective in understanding energy usage trends over time. AI systems can identify seasonal, daily, and even hourly fluctuations in energy consumption, enabling providers to forecast periods of high and low demand (Khan t al., 2022). This forecasting ability facilitates more accurate planning for energy distribution, helping reduce the likelihood of shortages or surpluses. By anticipating energy needs, utilities can optimize the operation of energy transmission systems, thereby reducing inefficiencies and ensuring that energy is delivered efficiently to end-users.

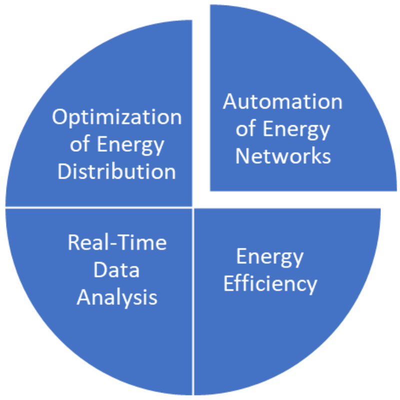

Fig 1: The Role of AI in Wireless Energy Transmission

Another transformative impact of AI on wireless energy transmission is the automation of energy networks. The development of self-healing grids is one of the key innovations in this area. A self-healing grid refers to an automated system that can detect faults or disruptions in the network, isolate the problem, and reroute power without human intervention. AI plays a central role in this process by using real-time data from sensors and smart meters to identify issues in the grid and initiate corrective actions (Rind *et al*., 2023). This reduces downtime, minimizes the impact of failures, and improves the overall reliability of the energy transmission system. In conjunction with self-healing grids, smart meters and sensors powered by AI offer real-time monitoring and control of energy usage. These devices continuously collect data on energy consumption and network performance, which AI algorithms analyze to identify patterns and trends. This data-driven approach enables utilities to proactively manage energy flows, detect inefficiencies, and enhance overall system performance. Additionally, smart meters equipped with AI can provide consumers with more detailed insights into their energy consumption, enabling them to make more informed decisions about their energy usage and contribute to overall energy savings.

AI is also making significant strides in improving energy efficiency, a crucial aspect of reducing overall energy consumption and minimizing environmental impact (Farzaneh *et al*., 2021). One of the primary ways AI contributes to energy efficiency is by reducing energy loss during transmission. Energy loss is an inherent challenge in traditional energy grids, especially in long-distance transmission. AI models can analyze transmission data and optimize the routing of power through the grid, identifying the most efficient pathways and minimizing losses that occur due to resistance in power lines or inefficient routing. Furthermore, AI can help identify inefficiencies within the energy transmission system itself. By continuously monitoring system performance and analyzing data from various sources, AI algorithms can detect deviations from optimal operation and pinpoint areas where energy is being wasted.

AI-driven real-time data analysis plays an essential role in the management of wireless energy transmission. Dynamic pricing, which involves adjusting the cost of energy based on real-time supply and demand, is one area where AI can make a substantial impact (Ruan *et al*., 2022). By analyzing data in real time, AI can predict fluctuations in energy demand and supply, allowing energy providers to adjust prices accordingly. This not only ensures that energy is allocated efficiently but also incentivizes consumers to adjust their usage patterns, reducing peak demand and helping to avoid grid congestion. In addition to dynamic pricing, AI's real-time data analysis capabilities enhance decision-making for energy allocation. Energy providers can use AI to assess data from multiple sources, including sensors, weather forecasts, and historical usage patterns, to make more informed decisions about where and how to allocate resources. This leads to improved decision-making regarding energy distribution, better utilization of renewable energy sources, and a more stable energy grid overall. The role of AI in wireless energy transmission is multifaceted, touching on aspects ranging from energy distribution optimization to real-time data analysis. Through advanced AI algorithms and automation, energy grids are becoming more adaptive and efficient, ensuring a stable and sustainable energy supply. By improving energy efficiency, automating grid management, and enabling predictive analytics, AI is helping create smarter, more resilient energy systems. As wireless energy transmission technology continues to evolve, the integration of AI will undoubtedly play a pivotal role in shaping the future of global energy networks, providing solutions to some of the most pressing challenges in energy distribution and consumption (Liu *et al*., 2022; Zeb *et al*., 2022).

2.2 Accounting Implications

The integration of Artificial Intelligence (AI) into wireless energy transmission systems in smart cities represents a significant shift in how energy is distributed and consumed (Yigitcanlar *et al*., 2021). This transformation brings with it several accounting implications that must be carefully managed to ensure the financial sustainability and operational success of such systems. From capital investments to incentives, revenue recognition, and cost-benefit analyses, each aspect presents unique challenges for accounting professionals. This examines the key accounting implications of AI-driven wireless energy systems, with a focus on cost structures, incentives, revenue recognition, cost-benefit analysis, and financial risks.

The adoption of AI-powered wireless energy transmission systems involves substantial capital costs, which can vary depending on the complexity of the technology and the scale of the energy network. These systems require significant upfront investments in hardware, such as energy transmission infrastructure, smart meters, sensors, and AI software. AI integration also necessitates the development or acquisition of sophisticated data analytics platforms, machine learning models, and automation technologies (Himeur *et al*., 2023). These capital costs need to be accurately accounted for, as they will directly affect the financial viability of energy projects in smart cities. These investments are typically capitalized on the balance sheet and depreciated over the useful life of the assets. Operational expenses related to AI integration further contribute to the overall cost structure. These expenses include ongoing maintenance of AI systems, software upgrades, and the training of personnel to operate and manage the technology. The continuous need for software updates to improve system performance or security, especially in response to emerging cybersecurity threats, adds to operational costs (Djenna *et al*., 2021). AI systems in energy transmission also require periodic recalibration and monitoring to ensure accuracy in energy distribution and consumption forecasting. These operational expenses must be carefully tracked and reported, as they can significantly impact the profitability of energy providers. The depreciation and amortization of AI technology assets are crucial accounting considerations in the context of wireless energy transmission. Given the rapid pace of technological advancement, AI systems may have shorter lifecycles compared to traditional assets. Depreciation schedules must reflect the technological obsolescence of AI systems, ensuring that the depreciation expense appropriately matches the asset's useful life. In some cases, AI software and related intellectual property may be subject to amortization instead of depreciation, depending on the accounting standards applicable.

AI and renewable energy technologies often attract various government subsidies, tax credits, and grants aimed at encouraging their adoption (Chen *et al*., 2021). These incentives play a significant role in shaping the financial landscape for businesses adopting AI-driven wireless energy systems. Accounting for these incentives requires careful consideration of how they are recognized in financial statements. Governments may offer incentives to offset the substantial initial capital costs of energy infrastructure, and these incentives often take the form of upfront tax credits or grants. These financial benefits can directly reduce the overall investment required by energy providers, enhancing the attractiveness of these technologies. The impact of government incentives on financial statements is profound. These incentives are typically recognized as a reduction in the cost of assets or as deferred income, depending on the nature of the grant. Accounting for these incentives ensures that businesses comply with financial reporting requirements while taking full advantage of available programs. There are also specific financial reporting requirements associated with incentive-based programs. This includes proper disclosure of the terms and conditions of incentive agreements, as well as their impact on financial statements, such as income statements and balance sheets. Failure to account for these incentives properly could lead to regulatory scrutiny or misrepresentation of financial health.

Revenue recognition in the context of AI-enhanced wireless energy systems is evolving, particularly due to the influence of AI optimization and dynamic pricing models. AI enables the development of dynamic pricing strategies, where energy costs fluctuate in real-time based on demand, weather conditions, and supply (Onukwulu *et al*., 2023). This dynamic pricing introduces complexities in revenue recognition, as energy providers must account for the variability in prices and the timing of revenue generation. Accounting for these fluctuations requires sophisticated models to track the recognition of revenue in periods when energy prices are high or low, ensuring that revenue is accurately recognized in accordance with accounting principles. In addition to dynamic pricing, usage-based revenue streams are increasingly common in the energy sector. These models, which charge consumers based on their actual energy consumption, align well with AI's ability to optimize energy distribution. The integration of smart meters and AI-driven systems allows energy providers to collect data on usage in real-time, enabling more accurate billing. The revenue from these usage-based models must be recognized as it is earned, with proper allocation based on usage and pricing, which may vary by time of day or season. AI also enables partnerships and collaborations in the energy sector, such as joint ventures between municipalities, energy providers, and technology firms. Accounting for these partnerships requires careful consideration of how revenue and costs are shared, and how the financial impact of these collaborations is reported (Karam *et al*., 2021). Joint ventures may involve shared investments and profits, so clear agreements must be made to allocate revenue and costs appropriately, ensuring accurate reporting and compliance with accounting standards.

One of the key drivers for the adoption of AI-powered wireless energy systems is the potential for long-term savings. A thorough cost-benefit analysis is essential to evaluate the economic feasibility of these systems. While initial investments in AI and wireless energy infrastructure can be substantial, the operational savings over time due to improved efficiency, reduced energy losses, and predictive maintenance can justify these costs. Evaluating the return on investment (ROI) for AI-driven systems is crucial for determining the financial viability of these technologies (Taherizadeh and Beaudry, 2023). AI can drive significant efficiencies, but the scale of these savings may vary depending on the size and complexity of the energy network. A comprehensive ROI analysis will take into account the upfront capital investment, operational costs, and the expected savings over time. This evaluation helps businesses and investors make informed decisions about whether to proceed with large-scale AI integration. The break-even point for smart energy investments, where the savings or revenue generated from AI integration equals the initial investment, is another important financial metric. Determining the break-even point helps businesses assess the timeline for achieving profitability and understand the financial risks involved in deploying AI-powered wireless energy transmission systems.

Adopting AI-powered energy systems comes with various financial risks. These risks include technical failures, which may disrupt energy transmission or cause system downtimes, leading to lost revenue and repair costs. Furthermore, cybersecurity threats are a growing concern, as AI systems may be vulnerable to hacking, potentially resulting in significant financial and reputational damage (Guembe *et al*., 2022). Ensuring that these risks are mitigated requires robust cybersecurity measures, including encryption and regular system audits. The volatility of energy markets poses additional risks to financial stability. Price fluctuations due to changes in supply, demand, or external factors (e.g., geopolitical events or natural disasters) can impact revenue projections. Additionally, regulatory changes could affect the financial model of AI-powered energy systems. Finally, the potential for system inefficiencies or mismanagement introduces uncertainty regarding the long-term financial performance of AI-powered wireless energy systems. Proper financial oversight, risk assessment, and scenario planning are essential to managing these uncertainties and ensuring sustainable financial outcomes.

The accounting implications of AI-driven wireless energy transmission in smart cities are multifaceted and complex. From capital investment and operational expenses to revenue recognition and incentives, each area requires careful consideration to ensure financial sustainability. As AI continues to optimize energy systems, understanding and managing these accounting implications will be critical for ensuring that businesses and municipalities can fully capitalize on the benefits of this transformative technology while mitigating the associated financial risks (Mondejar *et al*., 2021; Hassan *et al*., 2023).

2.3 Incentives for AI integration in wireless energy systems

As the demand for efficient, sustainable, and innovative energy solutions continues to grow, artificial intelligence (AI) is emerging as a key enabler in transforming wireless energy systems (Adelana et al., 2024). The integration of AI into energy grids, smart meters, and transmission technologies promises to enhance the efficiency, reliability, and sustainability of energy networks. However, widespread adoption of AI in wireless energy systems depends on various incentives that encourage investment, research, and development (Singh *et al*., 2022). These incentives come from governmental bodies, corporations, and economic considerations, ultimately shaping the adoption and impact of AI in energy systems as shown in figure 2.

Government incentives play a crucial role in driving the integration of AI into wireless energy systems, as they can lower the financial barriers associated with implementing advanced technologies. One of the primary incentives is the provision of tax breaks, rebates, and grants for the development of smart energy infrastructure. Governments worldwide recognize the need for upgrading existing energy grids and investing in intelligent systems that enhance energy efficiency and sustainability. Financial support in the form of tax breaks or direct subsidies for companies investing in AI-driven energy technologies can significantly reduce capital expenditures, making it easier for companies to deploy these systems at scale. In addition to direct financial incentives, government policies encouraging sustainable energy practices also act as key motivators for AI integration. Policies promoting the transition to renewable energy sources, reducing carbon emissions, and encouraging smart grid technologies create a favorable regulatory environment for AI adoption (Kabeyi and Olanrewaju, 2022). These policies often come with mandates for energy providers to integrate AI into their operations to meet sustainability goals or efficiency standards. The alignment of AI development with government sustainability objectives creates a powerful incentive for corporations to invest in the adoption of AI technologies, knowing that compliance with regulations could lead to both financial rewards and improved market positioning.

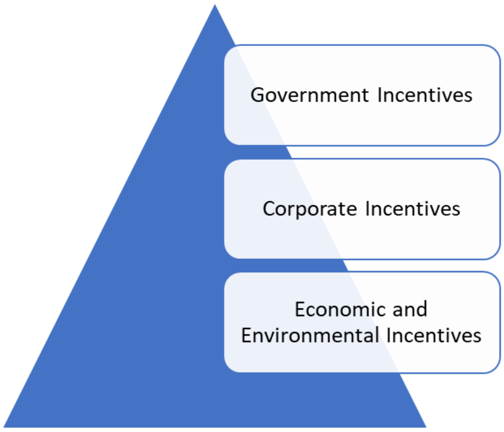

Fig 2: Incentives for AI Integration in Wireless Energy Systems

Corporations stand to benefit from AI integration in wireless energy systems, and as such, various corporate incentives have emerged to promote the widespread adoption of these technologies. One of the most prominent corporate incentives is the implementation of profit-sharing models based on energy savings. Energy providers and developers of AI-driven energy solutions can benefit from the substantial cost savings achieved through optimized energy distribution and reduced waste. In many cases, energy providers may enter into profit-sharing agreements with stakeholders, where the savings generated by AI-based systems are shared among the various parties involved (Rabieinejad *et al.*, 2021; Erman and Furendal, 2022). This creates a strong incentive for corporations to adopt AI, as the financial rewards from energy savings can offset the initial investment and generate long-term returns. Additionally, performance-based incentives for AI developers and energy providers are becoming increasingly common. These incentives reward companies based on the efficiency and performance of the AI systems they implement. Performance-based incentives encourage innovation and competition among developers and providers, spurring the continuous improvement of AI technologies that can optimize wireless energy transmission.

The integration of AI into wireless energy systems offers significant economic and environmental incentives, making it a compelling solution for municipalities, businesses, and governments. From an economic standpoint, AI can help municipalities and businesses achieve substantial cost savings by improving the efficiency of energy distribution (Yigitcanlar *et al.*, 2021). AI-driven systems enable better demand forecasting, optimized energy routing, and the identification of inefficiencies in energy networks. These capabilities reduce operational costs, minimize waste, and improve the overall reliability of energy systems (Adeoba et al., 2024). Municipalities, in particular, benefit from lower energy costs and reduced maintenance expenses associated with energy grids, leading to substantial long-term savings. From an environmental perspective, the integration of AI into wireless energy systems supports sustainability goals by reducing carbon footprints. AI can play a critical role in improving the efficiency of renewable energy sources, ensuring that energy is distributed more effectively and reducing reliance on fossil fuels. By enabling more precise energy management, AI reduces the need for backup power generation, which often comes from polluting sources. Additionally, AI-powered smart grids can facilitate the integration of renewable energy into the grid by managing the variable nature of renewable energy sources like solar and wind. As governments and corporations strive to meet sustainability goals, AI in wireless energy systems is becoming a vital tool for reducing greenhouse gas emissions and achieving carbon neutrality targets.

The integration of AI into wireless energy systems has a profound impact on various stakeholders, including consumers, businesses, and governments. For consumers, AI-driven energy solutions can significantly influence behavior and adoption patterns. As AI-based systems enable real-time monitoring of energy consumption, consumers gain more control over their energy use, allowing them to make informed decisions that can lead to energy savings (Nishtar and Afzal, 2023). Moreover, dynamic pricing models powered by AI create incentives for consumers to shift their energy usage to off-peak hours, further promoting energy efficiency and reducing overall demand. The availability of detailed data on energy consumption can drive greater awareness among consumers about their environmental impact, motivating them to adopt energy-saving practices. For businesses, the integration of AI-driven energy solutions represents an opportunity to achieve a strong return on investment (ROI). Companies that develop and implement AI technologies for energy transmission can experience substantial economic returns, not only from the cost savings associated with more efficient energy use but also from the growing demand for sustainable solutions. As more businesses embrace sustainability as a core value, AI-enhanced energy systems provide a competitive advantage, particularly in industries where energy consumption is a significant operational cost. Additionally, businesses that adopt AI-powered energy management systems can enhance their reputation by showcasing their commitment to reducing their environmental footprint (Varghese, 2022).

Incentives for AI integration in wireless energy systems are varied and impactful, coming from governments, corporations, and broader economic and environmental considerations. Government incentives, such as tax breaks and policies promoting sustainable energy practices, provide essential financial support for AI adoption. Corporations benefit from profit-sharing models and performance-based incentives that encourage energy savings and innovation (Jamasb, 2021). Economic incentives, such as cost savings for municipalities and businesses, and environmental incentives related to sustainability and carbon reduction, further bolster the case for AI integration. As AI continues to evolve, its role in transforming energy systems will be driven by these diverse incentives, benefiting stakeholders across the board and contributing to a more efficient and sustainable energy future.

2.4 Financial Reporting and Transparency

As artificial intelligence (AI) continues to reshape the energy sector, particularly in the context of wireless energy transmission within smart cities, the importance of financial reporting and transparency becomes paramount. The integration of AI into energy infrastructure raises unique challenges and opportunities for businesses, investors, and regulators (Franki *et al.*, 2023). These challenges include the accurate disclosure of investments and expenditures related to AI systems, the valuation of AI assets, and the need to comply with relevant regulatory standards. This explores these key aspects of financial reporting, focusing on disclosure requirements, valuation of AI assets, and regulatory compliance.

One of the primary aspects of financial reporting for AI-powered wireless energy systems is the disclosure of investments and expenditures. The adoption of AI technologies involves substantial capital investments, both in hardware (such as energy transmission infrastructure and smart meters) and in software (AI algorithms, machine learning systems, and data analytics platforms). These investments must be reported accurately in the financial statements to provide a true and fair view of the financial health of an organization. AI expenditures including ongoing operational costs such as software updates, system maintenance, and employee training also need to be disclosed (Lins *et al*., 2021). These expenditures can be significant and may have a direct impact on an organization's profitability. For companies adopting AI technologies, these disclosures typically impact two key financial statements: the balance sheet and the income statement. On the balance sheet, AI-related investments are categorized as assets, specifically under property, plant, and equipment (for physical infrastructure) or intangible assets (for AI software and intellectual property). The capitalization of these expenditures is essential, as it reflects the long-term value of AI technology to the organization. Over time, as the AI systems are used, companies must depreciate or amortize these assets, impacting future income statements by spreading the cost of the technology over its useful life (Trușculescu and Drăghici, 2023). On the income statement, AI-related operational costs, including system maintenance, software updates, and other recurrent expenses, are typically classified under operating expenses. These ongoing costs affect profitability in the short term, so transparent reporting is essential to convey the financial implications of integrating AI into energy systems. Furthermore, any incentives or subsidies received for AI investments, such as government tax credits or renewable energy grants, must be disclosed appropriately to avoid any misrepresentation of financial performance.

The valuation of AI assets poses another critical challenge in the context of financial reporting. Unlike traditional assets, AI technology is often classified as an intangible asset, given its nature as software or intellectual property (Yi *et al*., 2023). The valuation of intangible assets is more complex than tangible assets because these assets do not have a physical presence and their future economic benefits are often uncertain. In the case of AI systems in energy transmission, the value of the AI software which could include machine learning models, predictive analytics algorithms, and optimization tools needs to be determined through a combination of cost-based, market-based, and income-based approaches. Fair value assessment of AI assets is crucial for accurate financial reporting. The fair value of AI systems should reflect what the asset could be sold for in an open market transaction or, in the case of non-saleable assets, the present value of future economic benefits expected from the technology. Given the rapid pace of technological advancement, AI systems may depreciate faster than traditional assets, which can impact their fair value over time. Financial analysts must carefully assess and adjust the value of these AI assets as market conditions, technological advances, or energy industry regulations evolve. Regular re-assessment and adjustment of the AI asset's fair value are necessary to ensure that reported values align with their real-world utility and market perceptions. In the absence of an established market for specific AI systems, companies often rely on internal estimates based on expected future cash flows generated by the technology. These estimates require careful consideration of the anticipated benefits derived from improved energy distribution, cost savings, and efficiency gains. The intangible nature of AI also introduces significant subjectivity into the valuation process, which underscores the importance of transparency in the methodologies used to determine fair value (Althabatah *et al*., 2023).

As the integration of AI into energy systems grows, so does the need for compliance with a range of regulatory standards and frameworks designed to ensure that energy providers meet both financial and sustainability goals. Regulatory frameworks for AI in energy typically address safety, security, transparency, and ethical considerations (Lescrauwaet *et al*., 2022). In the context of financial reporting, these regulations require that companies disclose how their AI systems comply with these standards, ensuring that financial statements reflect not only the technical and operational aspects of AI but also the ethical and legal considerations surrounding its use. For AI-powered wireless energy systems, reporting compliance with sustainability initiatives is another crucial aspect. Many governments and international organizations have set green energy targets and sustainability goals, aiming to reduce carbon emissions, promote renewable energy adoption, and enhance energy efficiency. As part of these initiatives, businesses integrating AI into their energy transmission systems must disclose their efforts to contribute to these targets in their financial reports. Furthermore, environmental, social, and governance (ESG) reporting has become increasingly important for investors, regulators, and consumers. AI systems in energy transmission can play a significant role in helping businesses meet their sustainability objectives, but these contributions must be accurately reported in the context of overall ESG compliance (Saxena *et al*., 2022; Alkaraan *et al*., 2022). This includes providing evidence that AI technologies support energy conservation, optimize energy usage, and reduce environmental impact. Companies that fail to report these efforts transparently risk reputational damage and financial penalties, particularly as stakeholders demand greater accountability in the face of global environmental challenges. Regulatory bodies may also require audits of AI systems to assess their fairness, accuracy, and transparency. These audits ensure that AI algorithms do not perpetuate bias or inefficiencies and that they operate within the legal and regulatory frameworks of the jurisdiction. For example, companies might need to disclose how their AI systems ensure fair energy pricing and how pricing decisions align with market fairness regulations.

In the era of AI-powered wireless energy systems, financial reporting and transparency are crucial for accurately reflecting the economic and operational realities of these advanced technologies. From disclosing AI investments and expenditures to valuing intangible assets and ensuring regulatory compliance, businesses must adopt rigorous reporting practices to maintain financial integrity (Elumilade *et al*., 2022). The transparency of AI asset valuation, the accurate reflection of government incentives, and adherence to sustainability regulations will help build trust with investors, consumers, and regulators. As AI continues to shape the future of energy, maintaining high standards of financial reporting will be essential for ensuring the success and long-term sustainability of these cutting-edge systems.

2.5 Future implications and challenges

The integration of artificial intelligence (AI) into wireless energy systems holds tremendous promise for improving energy efficiency, reducing environmental impact, and transforming the way energy is distributed and consumed as shown in figure 3 (Albreem *et al*., 2021; Zohuri *et al*., 2022). However, as the technology continues to evolve and scale, several implications and challenges arise, particularly related to scalability, financial sustainability, and integration with broader smart city infrastructure. Addressing these challenges will be crucial to ensuring the long-term success and effectiveness of AI-driven wireless energy systems.

One of the primary challenges for AI-driven wireless energy systems lies in scalability particularly in accounting for future growth and expansion costs. As AI technologies become more widespread and integrated into wireless energy grids, energy demand is expected to increase, driven by population growth, urbanization, and the increasing adoption of connected devices (Strielkowski *et al*., 2021; Esenogho *et al*., 2022). Consequently, energy networks must scale accordingly to meet these demands. However, this expansion can be expensive, especially when integrating new AI algorithms, communication technologies, and energy infrastructure. The costs associated with upgrading legacy systems, maintaining AI-based networks, and providing adequate support for expanding infrastructure could pose significant barriers to scalability.

Furthermore, anticipating technological advancements in AI and energy systems is essential for long-term scalability. While AI can currently optimize energy distribution and enhance the performance of wireless energy systems, future developments in AI, machine learning, and energy transmission technologies are expected to further improve efficiency and capabilities. For instance, breakthroughs in quantum computing, edge computing, and next-generation AI algorithms could dramatically enhance the ability to process vast amounts of energy data and optimize transmission in real time. As such, energy providers must plan for these advancements to ensure their systems are adaptable and can incorporate these future technologies without requiring complete overhauls or incurring prohibitive costs (Mohd Aman *et al*., 2021; Mahmood *et al*., 2022).

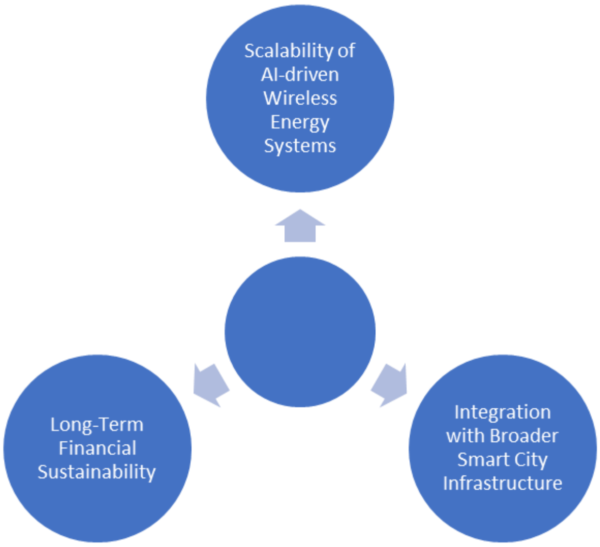

Fig 3: Future Implications and Challenges

Managing the long-term financial sustainability of AI and wireless energy systems is another key challenge (Lipu *et al*., 2022). While AI offers clear short-term benefits in terms of energy optimization and cost savings, the lifecycle costs of AI-driven energy systems must be carefully managed over time. These systems require substantial initial investments in infrastructure, hardware, and software development. Additionally, continuous system maintenance, updates, and training of AI models to accommodate evolving data and changing grid conditions can result in ongoing operational expenses. As such, managing lifecycle costs both upfront and ongoing will be critical to ensuring the financial sustainability of AI-driven wireless energy systems in the long term. Moreover, predicting the economic impacts of AI integration in energy systems over extended periods is complex. While AI-driven systems promise cost savings, the economic landscape is constantly changing. Fluctuations in energy prices, shifts in regulatory environments, and advances in competing technologies can all influence the financial viability of AI-powered energy networks. For instance, energy prices may fluctuate due to the availability of renewable energy or changes in fossil fuel markets. Additionally, the advent of new technologies, such as blockchain for energy trading or more efficient storage solutions, could disrupt the economic assumptions underpinning current AI energy systems (Aoun *et al*., 2021; Strengers *et al*., 2022). Therefore, energy providers and governments must continuously evaluate the economic performance of these systems to ensure their long-term financial viability, incorporating both short- and long-term financial strategies.

AI-driven wireless energy systems will play a pivotal role in the development of broader smart city infrastructure. A smart city is characterized by the integration of advanced technologies across various sectors energy, transportation, communication, and more to improve the quality of life, optimize resource usage, and create sustainable urban environments. The integration of AI into wireless energy systems will be essential to achieving these goals, but this integration also introduces a host of challenges (Waqas *et al*., 2022).

One of the most significant challenges lies in the role of AI in shaping the broader smart city financial ecosystem. AI-driven wireless energy systems must not only be financially viable on their own but also contribute to the overall economic efficiency of the smart city infrastructure. For instance, energy management in a smart city is closely linked with transportation and data systems. AI-powered energy systems need to coordinate with autonomous vehicles, public transportation, and communication networks to ensure efficient energy consumption across all connected systems (Bathla et a., 2022). This interconnectedness requires a holistic approach to financial planning and resource allocation, where the economic benefits of AI in one sector must be balanced with the costs in others. For example, the deployment of electric vehicles (EVs) within a smart city will increase energy demand, requiring careful coordination between energy systems and transportation infrastructure. Furthermore, the interdependencies between wireless energy, transportation, and data systems create additional complexities in accounting and financial management. The financial management of these interconnected systems requires new accounting models that can capture the full value created by synergies across multiple sectors. Traditional cost-benefit analyses may not fully capture the value of interconnected smart city systems, necessitating the development of new financial metrics that account for shared resources and interdependencies. Moreover, as smart cities evolve, the data generated by AI systems will become a valuable asset. Integrating AI-driven wireless energy systems with broader data ecosystems allows for advanced analytics that can inform decision-making, improve system performance, and create new revenue streams. However, monetizing this data while ensuring privacy and security will present new challenges. The economic value of energy data could be leveraged in various ways, including through energy trading platforms, improved urban planning, and predictive maintenance for infrastructure (Ahmad *et al*., 2022). As such, understanding the financial implications of these new data-driven business models will be crucial to the long-term success of AI in smart cities.

The future of AI-driven wireless energy systems presents both significant opportunities and considerable challenges. Scalability remains a critical concern, with the need to account for growth and technological advancements in both AI and energy infrastructure (Otoum and Mouftah, 2022). Long-term financial sustainability also poses challenges, requiring careful management of lifecycle costs and the ability to predict and adapt to economic shifts. The integration of AI within the broader context of smart city infrastructure adds further complexity, particularly when considering the interdependencies between energy, transportation, and data systems. Addressing these challenges will require innovative approaches to financial planning, technological development, and policy frameworks to ensure the success of AI-driven energy systems in the future.

3. Conclusion

In conclusion, the integration of AI-powered wireless energy transmission systems within smart cities brings forth several key accounting considerations that must be meticulously managed. The capital costs associated with AI technologies, ongoing operational expenditures, and the depreciation of AI assets represent significant aspects of financial reporting. Moreover, government incentives, such as subsidies, tax credits, and grants, play a critical role in reducing initial capital outlays and must be properly disclosed in financial statements. Accurate revenue recognition practices, particularly with dynamic pricing models and usage-based revenue streams, are essential for capturing the financial dynamics of AI-driven energy systems. Additionally, the valuation of AI assets, particularly the treatment of intangible assets and the fair value of AI systems, requires careful consideration to reflect the evolving nature of these technologies.

The importance of transparent and strategic accounting practices cannot be overstated. As AI technologies reshape the energy sector, ensuring that financial reporting accurately reflects both the costs and benefits of these innovations is critical for long-term success. Transparent accounting practices provide stakeholders with clear insights into the financial health of organizations adopting AI-driven energy solutions, fostering trust and supporting informed decision-making. Strategic financial planning ensures that the initial investments in AI technologies are aligned with long-term goals, optimizing profitability, efficiency, and sustainability. These practices will be crucial for maintaining the viability and growth of AI-powered smart city infrastructure, allowing cities to effectively integrate and scale AI technologies in their energy systems.

Looking ahead, the future outlook for smart cities and AI integration in the energy sector is promising. As technologies advance, we can expect greater automation, efficiency, and sustainability in energy distribution. AI's role in optimizing energy transmission will likely expand, supported by ongoing advancements in machine learning and data analytics. Additionally, government policies will continue to evolve to incentivize the adoption of renewable energy and AI technologies, further driving growth in this sector. The integration of AI in smart cities will ultimately lead to more efficient, sustainable, and resilient urban environments, making the development of robust accounting frameworks essential to navigating this rapidly changing landscape.

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