

Chapter 15

Integration of Renewable Energy in Smart Cities Towards a Clean and Sustainable Future

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ABSTRACT

In the face of rapid urbanization and growing environmental challenges, integrating renewable energy into smart cities has become a global priority. This chapter examines the challenges, opportunities and future prospects of this major energy transition. By harnessing energy sources such as solar, wind, biomass and hydroelectricity, smart cities are diversifying their energy supply, reducing their dependence on fossil fuels. This diversification not only responds to environmental issues, but also stimulates economic development. However, this transition is not without its challenges. The variability of renewable energy sources requires innovative energy storage and management solutions to ensure a stable and reliable power supply. Despite these challenges, the integration of renewable energy in smart cities has considerable potential to promote sustainable urban development by reducing carbon emissions, improving energy resilience and fostering more inclusive and eco-responsible communities.

1. INTRODUCTION

The gradual increase in demand for energy is a consequence of technological advances that improve comfort and access to technology, as well as population growth. This has led to a requirement for an expansion of the power distribution capacity. Current electricity systems rely primarily on fossil fuels

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(such as coal, gas, and oil) or nuclear energy, which pose significant and irreversible risks to the environment by emitting greenhouse gases (Mahmood et al., 2021). At present, urban areas account for approximately 80% of the world's energy consumption and are responsible for more than 60% of global greenhouse gas emissions (United Nations, 2024). In order to respond effectively to the urban energy demand and achieve the sustainable development goals, there is a growing development of smart and sustainable cities ("Waste Heat Recovery from Diesel Engines Based on Organic Rankine Cycle," 2024). Over the past two decades, the concept of the smart city has evolved considerably, becoming a significant and increasingly relevant solution for achieving urban sustainability ("Recommender Systems for Smart Cities," 2024). A number of cities, municipalities, and local communities around the globe are developing strategies to transform their region's energy supply into a sustainable energy system for the future (Thellufsen et al., 2020). Energy is a significant factor in the advancement of intelligent concepts for the development of urban areas and industrial sectors ("Transition vers un système énergétique durable pour les villes et les industries intelligentes," 2024). The energy systems of smart cities must be capable of meeting the growing demand for energy for heat and power generation. In order to meet the aforementioned demand, it is necessary for cities to implement energy conservation practices and utilize clean energy generation technologies, such as renewable energy sources (including solar, wind, biomass and hydroelectric power) in order to achieve a more environmentally-friendly approach. The integration of renewable systems into smart cities has a direct impact on the well-being and satisfaction of residents, as it contributes to the creation of more beneficial urban environments. It is therefore imperative that these technologies are adopted in order to guarantee the sustainable production of energy without the emission of greenhouse gases, thus promoting a healthier and more sustainable living environment ("A Review of Artificial Intelligence-Based Optimization Techniques for the Sizing of Integrated Renewable Energy Systems in Smart Cities," 2024).

2. ROLE OF SMART ENERGY SYSTEM BASED ON RENEWABLE ENERGIES

The energy system plays a pivotal role in the heart of smart cities, serving as a foundational element for the transition to a sustainable urban lifestyle. It is of the utmost importance to guarantee a dependable, effective, and environmentally conscious energy supply in order to facilitate the advancement of smart cities ("Energy Management and Planning in Smart Cities," 2024). The implementation of smart grids plays a pivotal role in the modernization of modern public life, encompassing three key areas. Firstly, they enhance the efficacy of the electrical system by integrating automation, monitoring, remote control, micro grid and self-repair capabilities. Furthermore, they furnish users with precise data regarding their energy consumption, expenditures, and the array of energy alternatives available. Finally, they facilitate the integration and use of distributed and renewable energy resources within existing systems ("Hybrid-Cloud-Based Data Processing for Power System Monitoring in Smart Grids," 2024; "Méthodes de contrôle des micro-réseaux pour parvenir à une gestion énergétique durable," 2024). The primary objective of smart energy is to fulfill current and future energy demand through the use of renewable energy sources that are sustainable and environmentally friendly, while simultaneously ensuring the sustainability of non-renewable sources and minimizing the environmental impact of energy production and consumption (Thellufsen et al., 2020). Although renewable energies represent one of the most promising clean resources for meeting the growing demand for energy, numerous scientific studies and research initiatives are currently focused on the integration of these renewable resources in smart cities

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