Cadernos de Pós-Graduação em Direito Político e Econômico
Published by: Centro de Estudos Acadêmicos Press
ISSN: 1678-2127
Volume 26 *Issue 2,* 2026
Website: https://ceapress.org

Improving Smart City Energy Efficiency with the Use of Artificial Intelligence and Machine Learning Methods

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Submission: 24.01.2026. Accepted: 12.06.2026. Publication: 02.08.2026

Abstract:
One response to urbanization's fast pace and the pressing need for sustainable development has been the emergence of "smart cities," which rely heavily on technological means of efficient resource management. A smart city can improve its energy efficiency by utilizing AI and ML techniques. Artificial intelligence (AI) powered solutions can help smart cities' energy systems distribute power more efficiently, reduce waste, and achieve real-time demand and supply balance. Predictive analytics and deep learning are two examples of machine learning algorithms that may properly estimate a building's future energy use and provide creative solutions to reduce that consumption. Among the most significant AI and ML techniques employed in energy optimization are smart grids, energy systems enabled by the Internet of Things, and adaptive algorithms for load balancing. It goes on to mention the challenges of implementing AI in smart city systems, including concerns over privacy and data security as well as the requirement for extremely strong computing resources. Smart communities can achieve their sustainability goals by keeping an eye on future trends and considering how AI and ML could impact energy management.

Keywords: Smart cities, energy optimization, artificial intelligence (AI), machine learning (ML), smart grids

Introduction:

There is mounting demand on cities to reduce their environmental impact while making better use of their resources as their populations rise. To address these issues, the concept of "smart cities" has emerged. These urban areas have embraced technological advancements to create a more sustainable, efficient, and livable environment. In order to make cities more sustainable and reduce their carbon footprint, optimizing energy usage is a key component of smart cities. Energy management in smart cities entails reducing overall consumption and ensuring smarter and more effective use of energy. Machine learning (ML) and AI are useful tools for this purpose. Using ML and AI, cities can build systems that adapt to fluctuating energy demands, optimize consumption and production in real time, and reduce waste. Cities can become more sustainable with the help of AI-powered energy solutions that improve electricity distribution, reduce waste, and forecast future energy needs. Specifically, AI and ML enable the interoperability of energy systems that are enabled by the Internet of Things (IoT) and smart grids. This allows for the real-time tracking, prediction, and optimization of energy use across many sectors, including residential, commercial, and industrial ones. These advancements pave

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the way for intelligent automation that can tailor energy consumption strategies to individual buildings and users, improve load balancing, and respond to real-time data. maximizing smart city energy efficiency with the application of AI and ML. In order to effectively control energy use, it discusses some of the most essential AI-based solutions, such as smart grids, flexible algorithms, and predictive analytics. Furthermore, the report delves into the challenges associated with using AI in smart city infrastructure, including concerns regarding data security and the requirement for robust computers. This article concludes that, in keeping with worldwide sustainability objectives, AI and ML can assist in making cities greener and more energy efficient.

Using AI and ML for Energy Efficiency Maximization

A revolutionary shift in smart city energy management may be possible with the integration of AI and ML for energy optimization. These technologies allow for more efficient and effective use of energy by automating distribution systems, altering supply in response to predicted demand, and improving overall energy usage. Machine learning and artificial intelligence sift thru mountains of data gathered from sensors, smart meters, and IoT devices to reveal patterns in energy consumption as they happen and enable real-time adjustments to reduce inefficiencies and increase efficiency.

.1 Predictive Analytics for Energy Forecasting

Predictive analytics is one of the most useful ways that AI and ML are used to save energy. ML systems can figure out how much energy a building will need in the future by looking at past energy use data along with outside factors like weather, time of day, and occupancy rates. These predictive models make it possible to make more accurate predictions, which lets energy companies and city leaders improve the production and distribution of energy in real time.

Predictive analytics not only helps predict times of high demand, but it also lets people take action before they happen to avoid energy shortages or overloads. For example, smart grids can change how much power they produce based on what they think the demand will be. This makes sure that there is energy when it is needed and not too much is produced. Cities will use less energy and leave less carbon behind.

2 Deep Learning Models for Real-Time Energy Management

By handling huge amounts of data in real time, deep learning, a type of machine learning, is a key part of making energy use more efficient. Deep learning models, especially neural networks, can find trends and oddities in how energy is used that other models might miss. For instance, deep learning algorithms can find buildings that are wasting energy by finding things like lights or heaters that aren't needed and then automatically change the systems to save energy.

Deep learning models can also help homes and businesses control their energy in more personalized ways. These models can suggest or take steps to save energy by learning from how a person normally uses it. For example, they might change the thermostat during peak hours or turn off machines when they're not in use. This amount of automation not only saves energy but also makes things easier and more comfortable for people to use.

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.3 Adaptive Algorithms for Load Balancing

Adaptive algorithms that are driven by AI are needed to manage how energy is distributed across smart towns. Load balancing means distributing electricity so that there is a steady flow and no part of the grid is overloaded. Load balancing in older systems is often reactive, meaning that it only helps when demand changes after the fact. AI, on the other hand, lets you be proactive by predicting changes in load and making changes to how energy is distributed before they happen.

Based on real-time data from different parts of the city, machine learning algorithms can change how energy supplies are used. For example, adaptive algorithms can move energy from lower-priority uses to important services during times of high demand, like summer afternoons when air conditioning use is at its highest. This method helps keep the power grid from going out, keeps it from getting too busy, and makes it more energy efficient all around.

Load balancing based on AI also makes it easier for green energy sources like solar and wind power to connect to the power grid. Because the production of renewable energy changes over time, machine learning models can predict changes in the production of renewable energy and make changes to the energy mix to ensure a steady supply of power.

Conclusion

One of the most essential things that smart towns can do to become more environmentally friendly and sustainable is to make the most efficient use of energy by maximizing its utilization. In light of this transition, machine learning and artificial intelligence (AI) have emerged as extremely helpful tools, making it possible to administer energy in a more effective and data-driven manner. Thru the utilization of predictive analytics, deep learning models, and adaptive algorithms, smart cities are able to precisely forecast their energy requirements, achieve load balance, and incorporate renewable energy sources. Systems that are powered by artificial intelligence make it simpler to execute real-time monitoring and optimization of energy consumption. The overall efficiency is increased while the amount of waste is decreased. These technologies not only reduce the amount of energy that is consumed, but they also serve to improve the dependability and resilience of energy systems. The application of artificial intelligence and machine learning in energy management presents a number of challenges, including the protection of data, the quantity of work that must be done, and the integration of these technologies with pre-existing systems. On the other hand, the potential advantages are enormous. Artificial intelligence and machine learning will play a larger role in the process of making the most efficient use of energy as smart communities continue to expand. Cities have the ability to make significant progress in terms of energy efficiency if they take action to address the issues and make the most of the technology available to them. It will be easier for them to achieve their long-term sustainability goals and create a future that is cleaner and healthier for cities as a result of this.

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