AI-DRIVEN ENERGY OPTIMIZATION IN MUNICIPAL BUILDINGS: A CASE STUDY ON REDUCING CONSUMPTION AND EMISSIONS

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Overview

The research project leverages artificial intelligence (AI) to enable demand-based adjustments of heating, lighting, and other energy systems based on actual room usage. By integrating CO_2 sensors and LoRaWAN technology, the project captures real-time room usage data, which is then used to optimize energy consumption. This approach is particularly advantageous for the often intermittent use of municipal buildings, such as sports facilities, kindergartens, town halls, and meeting rooms, which are often heated even when not in use. A significant advantage of the approach is that CO_2 levels are assessed, which are emitted through breathing, as an indicator of presence. This ensures that no personal data is collected, protecting user privacy.

A key innovation of this project lies in the use of artificial intelligence (AI) to enable demand-based adjustments based on actual room usage. Previous measures primarily targeted predefined schedules and general optimizations to reduce heating energy consumption. The presented approach offers higher accuracy in recording and controlling energy consumption compared to traditional methods. The system learns user behavior and can pre-adjust heating, cooling, and other energy consumers, ensuring rooms are comfortably conditioned when needed. The integration of these intelligent algorithms into existing building management systems will create intelligent municipal buildings and transform them to significantly reduce energy consumption and CO_2 emissions.

Methods

The research focuses on the development and implementation of intelligent control systems using AI driven algorithms. LoRaWAN technology and CO_2 sensors will be employed to capture real-time room usage data, which will then be used to adjust heating, lighting, and other energy systems accordingly. The algorithms developed will enable demand-based adjustments, significantly improving energy efficiency. This approach leverages existing local ecosystems and infrastructure, minimizing the need for costly improvements to building insulation or replacement of existing energy technologies. Additionally, the project will explore the integration of renewable energy sources, such as electricity produced by wind parks and newly installed photovoltaics, into the intelligent building systems.

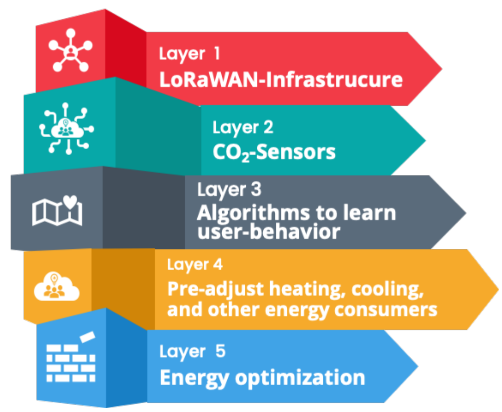

Figure 1: Layers of the AI-driven energy optimization

Results

In a preliminary project, wireless LoRaWAN infrastructure and sensors for measurements were installed to monitor energy consumption in municipal buildings. The establishment of an energy management system enabled the central visualisation of the building data. This infrastructure allowed for initial adjustments, resulting in first energy savings.

In the current research project the key innovation lies in intelligent and automated control. By employing artificial intelligence, demand-based adjustments of heating and electricity consumption can be made based on actual room usage. This integration of AI-driven automation with existing energy management systems has shown higher efficiency in controlling energy consumption compared to traditional methods. Preliminary results indicate that the introduction of automated energy control can achieve a sustainable reduction in energy consumption and CO_2 emissions by 15-20%. This also results in significant financial savings for municipalities. Results will be the implementation of algorithms and sensors in pilot buildings, evaluation of achieved energy savings and CO_2 reductions in the energy management system, and visualization in the open urban data platform. The project will provide data on energy-saving potential, and the developed algorithms can be integrated into other systems, which allows broad transferability of the solutions to other municipal buildings and regions. The scalability and replicability of the approach measures strongly support rural municipalities in meeting the challenging legal requirements related to energy efficiency and emissions reductions in the building sector, ensuring compliance with national and EU regulations.

Conclusions

The work highlights the potential for intelligent municipal buildings to serve as a model for other municipalities. The scalable nature of the developed algorithms allows for adaptation to various building types and regional contexts. By utilizing and expanding existing infrastructure, the project ensures easy replication and compliance with national and EU regulations related to energy efficiency and emissions reductions. The innovative use of AI and wireless technology provides a cost-effective solution for optimizing energy use without the need for extensive building modifications.

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